

TABLE OF CONTENTS

INTRODUCTION	I
CHAPTER ONE DRAINAGE	1-1
CHAPTER TWO EROSION AND SEDIMENT CONTROL	2-1
CHAPTER THREE STORMWATER TREATMENT	3-1
APPENDIX A METRIC CONVERSION FACTORS	A-1
APPENDIX B MANNING'S COEFFICIENT, n	B-1
APPENDIX C PIPE MATERIAL POLICY	C-1
APPENDIX D STORM SEWER POLICY	D-1
APPENDIX E DESIGN FORMS AND CHECKLISTS	E-1
APPENDIX F NOMOGRAPHS AND CHARTS FOR CULVERT DESIGN	F-1
APPENDIX G NOMOGRAPHS AND CHARTS FOR GUTTER FLOW AND INLET DESIGN	G-1
APPENDIX H NOMOGRAPHS AND CHARTS FOR STORM SEWER DESIGN	H-1
APPENDIX I CONDUIT DESIGN	I-1
APPENDIX J NOMOGRAPHS AND CHARTS FOR DESIGNING EARTH LOADS ON CONDUITS	J-1
APPENDIX K EQUATIONS FOR DRAINAGE DESIGN	K-1
APPENDIX L STORMWATER TREATMENT FORM A – PROJ. EVALUATION	L-1
APPENDIX M STORMWATER TREATMENT FORM B – STFs	M-1
APPENDIX N PRIORITY STORMWATER OUTFALLS	N-1
APPENDIX O REGULATED MS4 COMMUNITIES IN NEBRASKA	O-1
APPENDIX P STF DESIGN GUIDELINES	P-1
APPENDIX Q STORMWATER TREATMENT FORM C - MAINTENANCE	Q-1
APPENDIX R SELECTED NDOT OPERATING INSTRUCTIONS	R-1
APPENDIX S FLOODPLAIN POLICY	S-1
GLOSSARY	II-I
INDEX	i

TABLE OF CONTENTS

CHAPTER ONE DRAINAGE

1. DRAINAGE OBJECTIVES	1-2
2. LEGAL, REGULATORY AND ENVIRONMENTAL ISSUES	1-2
2.A <u>Drainage Law</u>	1-2
2.A.1 Drainage Easement	1-2
2.A.2 Disposal of Surface Water	1-3
2.A.3 Natural Watercourses	1-3
2.A.4 Flood Waters	1-3
2.A.5 Ground Waters	1-3
2.A.6 Waste, Artificial and Unnatural Waters	1-4
2.B <u>Regulatory and Environmental Issues</u>	1-4
3. COORDINATION WITH OTHER ENTITIES AND PUBLIC INVOLVEMENT	1-4
4. DESIGN CONSIDERATIONS	1-4
4.A <u>Economic Considerations</u>	1-4
4.B <u>Safety Considerations</u>	1-5
5. PRELIMINARY DRAINAGE DESIGN	1-5
5.A <u>Backround Information</u>	1-6
5.B <u>Mapping</u>	1-6
5.C <u>Floodplain Information</u>	1-6
5.D <u>Utilities</u>	1-9
5.E <u>Watershed Characteristics</u>	1-9
5.F <u>Land Use</u>	1-9
5.G <u>Existing Drainage Facilities</u>	1-9
5.H <u>Preliminary Layout</u>	1-9
5.I <u>Preliminary Design Checklist</u>	1-10
5.J <u>Field Visit</u>	1-10
6. HYDROLOGY	1-10
6.A <u>Factors Affecting Peak Runoff</u>	1-10
6.B <u>Probability and Frequency</u>	1-11
6.C <u>Design Storm Frequencies</u>	1-11
6.C.1 Culvert Design Storm	1-11
6.C.2 Storm Sewer Design Storm	1-12
6.D <u>Peak Runoff Design Methods</u>	1-13
6.D.1 Rational Method	1-13
6.D.1.a Coefficient of Runoff (C)	1-14
6.D.1.b Rainfall Intensity (i)	1-16
6.D.1.c Time of Concentration (T _c)	1-21
6.D.1.d Drainage Area (A)	1-23
6.D.2 Regression Equations	1-23

7.	OPEN CHANNELS	1-30
7.A	<u>General</u>	1-30
7.B	<u>Types of Open Channel Flow</u>	1-30
7.B.1	Critical Depth	1-31
7.B.2	Froude Number	1-32
7.C	<u>Open Channel Equations</u>	1-33
8.	CULVERT DESIGN	1-35
8.A	<u>Hydraulic Analysis</u>	1-35
8.A.1	New and Reconstructed Projects	1-35
8.A.2	3R Projects	1-35
8.A.3	Culvert Design Features	1-36
8.B	<u>Inlet and Outlet Control</u>	1-36
8.B.1	Inlet Control	1-37
8.B.2	Outlet Control	1-37
8.C	<u>Culvert Type, Material and Location</u>	1-38
8.D	<u>Culvert Lengths</u>	1-39
8.E	<u>Multiple Barrels and Spans</u>	1-42
8.F	<u>End Treatments</u>	1-42
8.G	<u>Headwater Elevation</u>	1-43
8.H	<u>Tailwater Elevation</u>	1-44
8.I	<u>Minimum Culvert Sizes</u>	1-44
8.J	<u>Hydraulic Design Procedure</u>	1-44
8.K	<u>Culvert Entrance Configurations</u>	1-46
8.K.1	Conventional Culvert Inlets	1-46
8.K.2	Improved Inlets	1-48
8.L	<u>Special Hydraulic Considerations</u>	1-51
8.L.1	Broken-Back Culverts	1-51
8.L.2	Irregular Profile and Alignment	1-53
8.L.3	Compound Bend Angle	1-54
8.L.4	Anchorage	1-55
8.M	<u>Debris Control</u>	1-55
8.N	<u>Corrosion and Abrasion</u>	1-56
8.O	<u>Multiple-Use Culverts</u>	1-56
8.P	<u>Culvert Extensions</u>	1-56
8.Q	<u>Structural Requirements</u>	1-57
8.R	<u>Culvert Excavation Measurement</u>	1-58
9.	PAVEMENT DRAINAGE	1-62
9.A	<u>Surface Drainage of Pavements</u>	1-62
10.	STORM SEWER SYSTEMS	1-63
10.A	<u>Storm Sewer Curb and Gutter Flow</u>	1-64
10.A.1	Gutter Flow Equations	1-66
10.A.2	Gutter Slopes	1-67

10.B	<u>Storm Sewer Inlets</u>	1-67
	10.B.1 Inlet Placement	1-71
	10.B.2 Curb Inlets	1-71
	10.B.2.a Capacity of Curb Inlets on Continuous Grade	1-72
	10.B.2.b Capacity of Curb Inlets in a Low Point or Sump	1-73
	10.B.3 Grate Inlets	1-73
	10.B.3.a Capacity of Grate Inlets on Continuous Grade	1-74
	10.B.3.b Capacity of Grate Inlets in a Low Point or Sump	1-76
	10.B.4 Slotted Pipe Inlets	1-76
	10.B.4.a Capacity of Slotted Pipe Inlets on Continuous Grade	1-77
	10.B.4.b Capacity of Slotted Pipe Inlets in a Low Point or Sump	1-77
	10.B.5 Slotted Vane Inlet	1-78
	10.B.6 Multiple Grate Inlets	1-79
10.C	<u>Storm Sewer Manholes and Junction Boxes</u>	1-79
	10.C.1 Location	1-79
10.D	<u>Storm Sewer Pipe</u>	1-80
	10.D.1 Manning's Equation for Open Channel Flow	1-81
10.E	<u>Storm Sewer Hydraulic Grade Line</u>	1-82
10.F	<u>Storm Sewer Energy Losses</u>	1-82
	10.F.1 Friction Losses	1-82
	10.F.2 Velocity Head Losses	1-83
	10.F.2.a Terminal and Entrance Losses	1-83
	10.F.2.b Junction Losses	1-83
	10.F.2.b.1 Incoming Opposing Flows	1-83
	10.F.2.b.2 Changes in Direction of Flow	1-84
	10.F.2.b.3 Several Entering Flows	1-85
11.	SANITARY SEWERS	1-87
12.	PIPE MATERIAL POLICY	1-88
13.	SPECIAL CONSTRUCTION	1-88
	13.A <u>Pavement Subdrains</u>	1-88
	13.B <u>Inverted Siphons</u>	1-88
	13.C <u>Boring and Jacking</u>	1-89
	13.D <u>Detention, Retention, and Sedimentation Basins</u>	1-91
14.	EXAMPLE PROBLEMS	1-92
	14.A <u>Rational Method</u>	1-92
	14.B <u>Regression Equations</u>	1-93
	14.C <u>Concrete Box Culvert Design</u>	1-94
	14.D <u>Curb and Gutter Flow</u>	1-97
	14.E <u>Capacity of Curb Inlet on Continuous Grade</u>	1-98
	14.F <u>Capacity of Curb Inlet in a Low Point or Sump</u>	1-99
	14.G <u>Capacity of Grate Inlet on a Continuous Grade</u>	1-100
	14.H <u>Capacity of Grate Inlet in a Low Point or Sump</u>	1-100
	14.H.1 Weir Condition	1-100
	14.H.2 Orifice Condition	1-101

14.I	<u>Capacity of a Slotted Pipe Inlet in a Low Point or Sump</u>	1-102
14.I.1	Weir Condition	1-102
14.I.2	Orifice Condition	1-102
14.J	<u>Capacity of a Slotted Pipe Inlet on a Continuous Grade</u>	1-102
14.K	<u>Capacity of Slotted Vane Inlet</u>	1-103
14.L	<u>Storm Sewer and Inlet System</u>	1-104
15.	REFERENCES	1-113

TABLE OF CONTENTS

CHAPTER TWO EROSION AND SEDIMENT CONTROL

1. EROSION AND SEDIMENT CONTROL OBJECTIVES	2-2
2. SAFETY AND AESTHETICS	2-4
3. GENERAL EROSION AND SEDIMENT CONTROL DESIGN CONSIDERATIONS	2-4
4. EROSION AND SEDIMENT CONTROL PLANS	2-5
5. TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES	2-6
5.A <u>Temporary Hydraulic Control Measures</u>	2-6
5.A.1 Temporary Slope Drain	2-6
5.B <u>Temporary Erosion Control Measures</u>	2-8
5.B.1 Covercrop Seeding	2-8
5.B.2 Temporary Seeding	2-8
5.B.3 Temporary Mulching	2-8
5.B.4 Temporary Slope Protection	2-9
5.B.5 Contour Field Cultivation of Slopes	2-9
5.C <u>Temporary Sediment Control Measures</u>	2-9
5.C.1 Temporary Erosion Checks	2-9
5.C.2 Temporary Earth Checks	2-10
5.C.3 Temporary Rock Checks	2-10
5.C.4 Temporary Silt Fence	2-10
5.C.5 Temporary Silt Trap	2-11
6. PERMANENT EROSION AND SEDIMENT CONTROL MEASURES	2-11
6.A <u>Permanent Erosion Control Measures</u>	2-13
6.A.1 Seeding	2-13
6.A.2 Mulching	2-13
6.A.3 Slope Protection	2-16
6.A.4 Contour Field Cultivation of Backslopes	2-16
6.A.5 Sodding	2-17
6.A.6 Erosion Control "Type__" Products	2-17
6.B <u>Permanent Sediment Control Measures</u>	2-22
6.B.1 Erosion Checks	2-22
6.B.2 Silt Fence	2-25
6.B.3 Slope Protection Netting	2-26

7.	PERMANENT HYDRAULIC CONTROL MEASURES	2-26
7.A	<u>Riprap</u>	2-26
	7.A.1 Sizing Riprap	2-27
	7.A.2 Tractive Force Theory	2-27
	7.A.3 Permissible Shear Stress	2-28
	7.A.4 Riprap Size	2-28
	7.A.5 Channel Bends	2-30
	7.A.6 Other Considerations	2-33
	7.A.6.a Riprap Gradation and Thickness	2-33
	7.A.6.b Filter Design	2-33
	7.A.7 Placing Riprap	2-34
	7.A.7.a Channel Bank Riprap	2-34
7.B	<u>Gabions</u>	2-37
7.C	<u>Revet Mattress</u>	2-39
7.D	<u>Cellular Confinement System</u>	2-39
7.E	<u>Curb and Flume</u>	2-40
	7.E.1 3 in. (75 mm) Curb	2-40
	7.E.2 Concrete Flumes	2-41
7.F	<u>Runoff Intercepting Methods</u>	2-42
	7.F.1 Intercepting Earth Dike	2-42
	7.F.2 Intercepting Ditch	2-44
	7.F.3 Backslope Drop Pipe	2-44
7.G	<u>Ditch Grade Control Structures</u>	2-46
	7.G.1 Drop Pipe	2-46
7.H	<u>Ditch Lining</u>	2-47
	7.H.1 Articulated Concrete Block Lining	2-48
	7.H.2 Cast-In-Place Concrete Ditch Lining	2-48
	7.H.3 Concrete Slope Protection	2-49
7.I	<u>Sediment Control</u>	2-49
	7.I.1 Sediment Trap	2-49
	7.I.1.a Design	2-49
	7.I.1.b Location	2-49
	7.I.1.c Storage Volume	2-50
	7.I.1.d Embankment	2-50
	7.I.1.e Outlet	2-50
	7.I.2 Sediment Basin	2-52
7.J	<u>Energy Dissipators</u>	2-53
	7.J.1 Preformed Scour Hole (Riprap Basin)	2-53
8.	REFERENCES	2-59

TABLE OF CONTENTS

CHAPTER THREE STORMWATER TREATMENT WITHIN MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) COMMUNITIES

1. STORMWATER TREATMENT OBJECTIVE	3-3
2. LEGAL AND REGULATORY	3-4
2.A <u>Municipal Separate Storm Sewer System (MS4) Permit</u>	3-4
2.A.1 Local Public Agencies	3-4
2.B <u>Total Maximum Daily Loads (TDMLs)</u>	3-4
2.B.1 Total Maximum Daily Loads (TDMLs) or Other Water Quality Requirements	3-5
2.C <u>Platte River Depletion</u>	3-5
2.C.1 <i>De Minimum</i> Threshold for Platte River Species Depletions Consultations	3-5
2.D <u>Legal, Regulatory and Environmental Issues Related to Drainage</u>	3-5
2.E <u>Designation of STFs</u>	3-6
3. PROJECT EVALUATION PROCESS	3-6
3.A <u>General Project Criteria</u>	3-6
3.A.1 3R and New and Reconstructed Projects	3-7
3.B <u>Preliminary Project Evaluation</u>	3-7
3.C <u>Final Project Evaluation</u>	3-8
3.D <u>RDC Coordination with Adjacent MS4 Community</u>	3-8
3.E <u>Change in Project Scope</u>	3-8
4. STORMWATER TREATMENT FACILITY DESIGN PROCESS	3-12
4.A <u>Plan-In-Hand Phase</u>	3-12
4.B <u>Public Hearing Phase</u>	3-12
5. STORMWATER OUTFALLS	3-12
5.A <u>Stormwater Outfalls</u>	3-12
5.A.1 Definitions	3-13
5.B <u>Priority Stormwater Outfalls</u>	3-13
5.B.1 Priority Stormwater Outfalls Off Project	3-15
5.C <u>Example Cases of Stormwater Outfalls</u>	3-15
6. STF HYDROLOGY	3-17
6.A <u>Water Quality Volume (WQV)</u>	3-17
6.A.1 Treatment Drainage Area	3-17
6.A.2 Selection of Water Quality Volume	3-17
6.B <u>Water Quality Volume Discharge Rate</u>	3-18
6.C <u>Addressing Stormwater Run-On</u>	3-19

7.	STF SELECTION AND PRELIMINARY DESIGN	3-22
7.A	<u>General Considerations</u>	3-22
	7.A.1 Online and Offline Treatment	3-22
	7.A.2 Safety and Aesthetics	3-23
	7.A.3 Coordination with Adjacent MS4	3-23
	7.A.4 Off-Site Stormwater Mitigation	3-24
	7.A.4.a On-Site Stormwater Mitigation	3-24
	7.A.5 Maintenance Responsibilities	3-25
	7.A.6 Right-of-Way Considerations	3-25
	7.A.6.a Retention of ROW for STFs	3-25
	7.A.7 Compliance with Chapter One - Drainage Design	3-26
7.B	<u>STF Selection Process</u>	3-26
	7.B.1 Existing Conditions	3-26
	7.B.2 STF Selection Guidance	3-26
	7.B.2.a Order of STF(s)	3-28
	7.B.2.b Site Conditions	3-28
	7.B.2.c Design STF for WQV	3-28
	7.B.2.d Combining STFs	3-29
	7.B.2.e Other Treatment Options or Project Alternative	3-29
7.C	<u>STF Summary</u>	3-29
	7.C.1 Vegetated Filter Strips	3-29
	7.C.2 Grass Swales	3-30
	7.C.3 Infiltration Trench	3-30
	7.C.4 Infiltration Basin	3-31
	7.C.5 Bioretention	3-31
	7.C.6 Media Filter	3-32
	7.C.7 Extended Dry Detention	3-32
	7.C.8 Wet Detention Pond	3-33
	7.C.9 Stormwater Wetland	3-34
	7.C.10 Pervious Pavement	3-34
	7.C.11 Proprietary Structural Treatment Control	3-35
	7.C.12 Other Reasonable Practices	3-35
8.	COMPLETING STF DESIGN	3-37
8.A	<u>Landscaping</u>	3-37
8.B	<u>Construction Phasing</u>	3-37
8.C	<u>Maintenance Schedule</u>	3-37
8.D	<u>Plan Labeling of STF</u>	3-38
8.E	<u>Miscellaneous</u>	3-38
	8.E.1 Fencing	3-38
	8.E.2 Signage	3-38
9.	REFERENCES	3-39